## REMARKS

Reconsideration of the January 14, 2003 Official Action is respectfully requested. Claims 1-20, as amended, are pending in the application for the Examiner's review and consideration.

### Rejections under 35 U.S.C. § 112

Claim 3 was rejected under 35 USC §112, second paragraph on the basis that the claim terminology "desired" is allegedly indefinite. Claim 3 has been amended to recite an oxygen-containing gas that maintains a thickness of the sidewall polymer effective for profile control of the etched openings. Support for this change can be found on page 8, lines 15-20 of the specification. As no new matter has been introduced, the amendment should be entered and the rejection withdrawn.

Claim 6 was rejected under 35 U.S.C. § 112, second paragraph, because the limitation "etch stop" allegedly lacks antecedent basis. This rejection is respectfully traversed. A definition of etch stop is provided in the specification at page 8, lines 5-14. Withdrawal of this rejection is respectfully requested.

### Objections under 37 C.F.R. § 1.84

In paragraph 6, on pages 4-5 of the Official Action, the drawings were objected to for failing to comply with 37 C.F.R. § 1.84(p)(5) for allegedly including "reference sign 20" not mentioned in the specification. Figure 3 actually shows reference numeral 12 rather than 20 and paragraph 36 of the specification has been amended to describe the straight openings as "straight openings 12." Accordingly, this objection should be withdrawn.

**Rejections under 35 U.S.C. § 103**

Claims 1-20 were rejected under 35 U.S.C. § 103(a) as being allegedly unpatentable over U.S. Patent Nos. 6,403,488 ("Yang"); 4,615,764 ("Bobbio") and 6,117,786 ("Khajehnouri"). The reasons for the rejection are set forth in numbered paragraph 5 on pages 2-4 of the Official Action. This rejection is respectfully traversed.

Reconsideration of the rejection is requested in view of the following legal precedent regarding rejections based on a combination of prior art references. First, in In re Vaeck, 20 USPQ2d 1438, 1442 (Fed. Cir. 1991), the court stated the following regarding a proper §103 rejection:

> "Where claimed subject matter has been rejected as obvious in view of a combination of prior art references, a proper analysis under §103 requires, *inter alia*, consideration of two factors: (1) whether the prior art would have suggested to those of ordinary skill in the art that they should ... carry out the claimed process; and (2) whether the prior art would have also revealed that in so making or carrying out, those of ordinary skill would have a reasonable expectation of success [citation omitted]. Both the suggestion and the reasonable expectation of success must be found in the prior art, not in applicant's disclosure." (Vaeck at 1442.)

In addition to the above, In re Imperato, 179 USPQ 730 (CCPA 1973) set forth the following regarding a proper combination of references:

> "With regard to the principal rejection, we agree that *combining* of Schaefer with that of Johnson or Amberg *would give the beneficial result observed by appellant*. However, the mere fact that those disclosures *can* be combined *does not make the combination obvious unless* the art also contains *something to suggest the desirability* of the combination." (Emphasis added) (Imperato at 732).

Claim 1 recites a method of etching openings in a dielectric layer with profile control, comprising (i) supporting a semiconductor substrate in a plasma etch reactor, the substrate including a dielectric layer; (ii) supplying an etchant gas to the plasma etch reactor; and (iii) etching openings in the dielectric layer by energizing the etchant gas into a plasma state, *the etchant gas comprising $C_xF_yH_z$ wherein $x \geq 1$, $y \geq 1$ and $z \geq 0$, $SO_2$ gas and an oxygen-containing gas*, the $SO_2$ gas and the oxygen-containing gas being added in amounts effective for profile control of the etched openings.

Yang discloses a method for plasma etching comprising etching a structure with a plasma prepared from a gas mixture comprising (i) an etching gas, and (ii) a strained cyclic (hydro) fluorocarbon gas (Abstract of Yang). Yang discloses that the reactive or etching gas which may be used includes $CHF_3$, $CH_2F_2$, $CHF_2CHF_3$, $C_2F_6$, mixtures thereof and additional "halocarbons" include $CF_4$, $SF_6$, $NF_3$, $SF_4$, $Cl_2$, HF, CHl, $CCl_4$, $C_nH_xF_y$ and mixtures thereof, preferably $CHF_3$ (column 2, lines 58-66 of Yang). Accordingly, Yang fails to disclose an etchant gas which includes $SO_2$.

In the Official Action, Bobbio is cited for a suggestion "to add oxidizing components including $O_2$ and $SO_2$ (sulfur-containing gas) in order to enhance etching selectivity of the oxide" (Official Action at page 3). Yang, however, teaches away from adding oxygen to the etching gas. In particular, Yang states that "CO may be formed during the etching process, but preferably CO is not added to the gas mixture" (column 3, lines 12-13 of Bobbio). As such, it is submitted that a person of ordinary skill in the art would not have been led by the teachings of Bobbio to add an oxygen-containing gas to the etch gas of Yang.

Bobbio discloses the addition of one or more oxidizing components to a gaseous mixture of $SF_6$ and a nitrogen containing compound (column 2, lines 5-10 of Bobbio). Bobbio states that a plasma comprising $SF_6$ alone is very selective for etching silicon over $SiO_2$ but the addition of a nitriding gas reverses this selectivity such that $SiO_2$ is etched at a faster rate than silicon or polysilicon (column 2, lines 13-17 of Bobbio). Bobbio states that in the addition of an oxidizing species the selectivity of the $SF_6/NH_3$ system can be significantly improved (column 2, lines 17-25 of Bobbio). Thus, while $SO_2$ is included in the list of oxidizing components of Bobbio, Bobbio only teaches the addition of $SO_2$ along with $SF_6$ and a nitrogen containing compound such as $NH_3$. Bobbio does not teach an etchant gas comprising $C_xF_yH_z$, $SO_2$ and an oxygen containing gas. As such, the combination of Yang and Bobbio cannot possibly produce the claimed method.

Khajehnouri is cited only with regard to Claim 6. Accordingly, Khajehnouri fails to cure the deficiencies of Yang and Bobbio noted above. As such, it is submitted that Claim 1 and the claims dependent thereon are clearly patentable over the combination of Yang, Bobbio and Khajehnouri.

It is submitted that the differences between the claimed subject matter and the prior art are such that the claimed subject matter, as a whole, would not have been obvious at the time the invention was made to a person having ordinary skill in the art.

In view of the foregoing, it is submitted that the present application is in condition for allowance and such action is earnestly solicited.

Respectfully submitted,

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Date: April 8, 2003

**Appendix A - Attachment to Amendment**

**Marked-up Specification (paragraph 36 at pages 16-17)**

Figure 1 illustrates the bowed etch profile obtained when using an etch gas mixture which includes $O_2$ but not $SO_2$ and Figure 2 illustrates the tapered etch profile obtained when the etch gas mixture includes $SO_2$ but not $O_2$. In Figure 1, a dielectric layer 2 having bowed openings 4 was obtained when the dielectric etch was carried out for about 4 minutes in a single step with the chamber pressure set at about 50 mTorr, one or both of the electrodes powered with 500 watts at 27 MHz and 2000 watts at 2 MHz, 500 sccm Ar, 7 sccm $O_2$, and 15 sccm $C_4F_8$. In Figure 2, a dielectric layer 6 having tapered openings 8 was obtained when the dielectric etch was carried out an oxide etch can be carried out for about 4 minutes in a single step with the chamber pressure set at about 30 mTorr, one or both of the electrodes powered with 1400 watts at 27 MHz and 1800 watts at 2 MHz, 500 sccm Ar, 13 sccm $SO_2$, and 15 sccm $C_4F_8$. Figure 3 shows an example of a dielectric layer 10 having straight openings 12, the openings being etched in accordance with the process according to the invention.

**Appendix B - Attachment to Amendment**

**Marked-up Claims 1, 3, 6, 7 and 12**

1. (As Amended) A method of etching openings in a dielectric layer with profile control, comprising:

supporting a semiconductor substrate in a plasma etch reactor, the substrate including a dielectric layer;

supplying an etchant gas to the plasma etch reactor; and

etching openings in the dielectric layer by energizing the etchant gas into a plasma state, the etchant gas comprising $C_xF_yH_z$ wherein $x \geq 1$, $y \geq 1$ and $z \geq 0$, [a sulfur-containing] $SO_2$ gas and an oxygen-containing gas, the [sulfur-containing] $SO_2$ gas and the oxygen-containing gas being added in amounts effective for profile control of the etched openings.

3. (As amended) The method of Claim 1, wherein the $C_xF_yH_z$ forms a protective sidewall polymer on sidewalls of the etched openings, the [sulfur-containing] $SO_2$ gas protects the sidewall polymer from excessive attack by the oxygen-containing gas and the oxygen-containing gas maintains a [desired] thickness of the sidewall polymer effective for profile control of the etched openings.

6. (As Amended) The method of Claim 1, wherein [the sulfur-containing gas is $SO_2$ and] the oxygen-containing gas is $O_2$, the $SO_2$ and $O_2$ being added in amounts effective to

provide undissociated $SO_2$ molecules which react with polymer at bottoms of the etched openings to prevent etch stop under bombardment of directional ions.

7. (As Amended) The method of Claim 1, wherein the ratio of flow rates of the [sulfur-containing] $SO_2$ gas to the oxygen-containing gas is 0.5:1 to 1.5:1.

12. (As Amended) The method of Claim 1, wherein [the sulfur-containing gas is $SO_2$ and] the oxygen-containing gas is $O_2$, each of the $SO_2$ and $O_2$ gases being supplied to the plasma etch reactor at a flow rate of 1 to 30 sccm.